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MCNA Technology Roadmap Development Report

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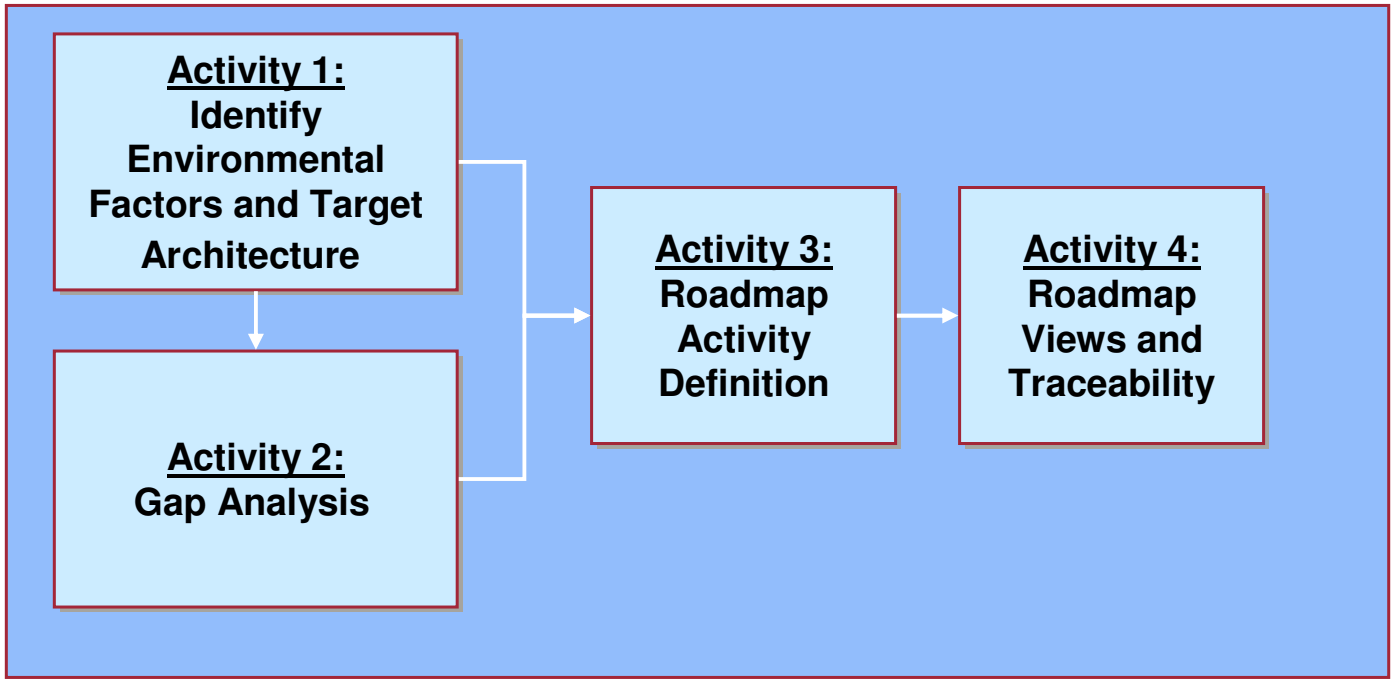
August 12, 2005

Objectives

- Identify gaps and characteristics or limitations that need to be addressed to implement the integrated (mobile and terrestrial) communication network architecture
- Draft a 10-year roadmap for the “2015” target system architecture

Gap Analysis and Roadmap Development Work Flow Diagram

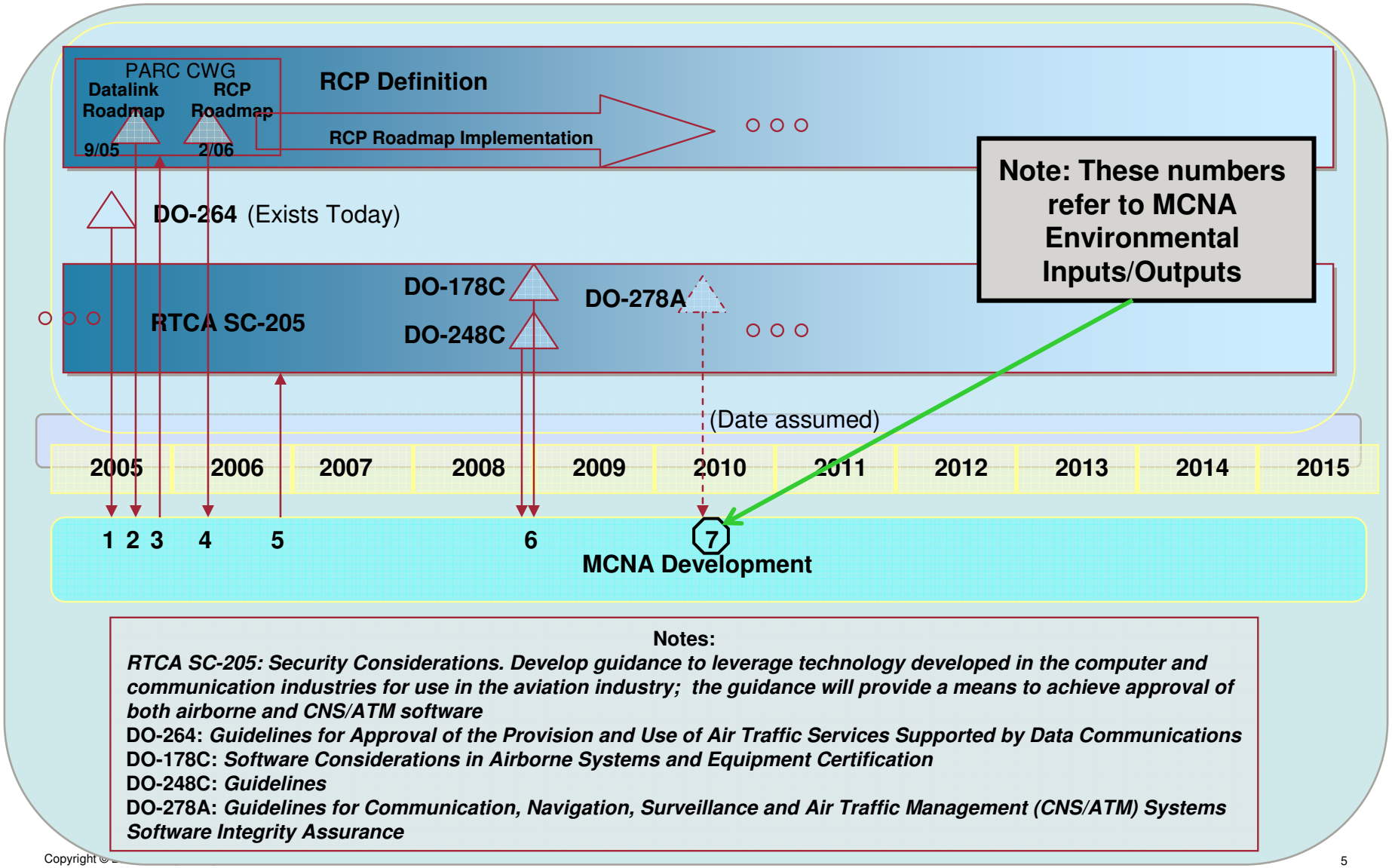
- **This task consisted of four principal activities closely tied to other MCNA development activities**



Activity 1: Environmental Elements and 2015 Concept Formulation

- This activity addressed the identification of environmental factors applicable to MCNA development and included formulation of a target 2015 MCNA concept
  - Environmental factors are those factors or activities that are external but intimately related to the MCNA development effort
    - Knowledge of these activities helps to specify meaningful elements of the MCNA roadmap (e.g. can use inputs from environmental activities or provide outputs to environmental activities)
    - These factors were addressed in five broad categories: Process Development; Link Technologies; Network Technologies; Security; System Integration
  - The target 2015 MCNA concept was developed based on material developed during MCNA functional analysis and architecture and transition planning development
    - Since the roadmap intends to lay out the necessary steps (and support investment planning) for achieving the 2015 target architecture, the type of capability/functionality expected in the 2015 timeframe needs to be captured

Activity 1: Environmental Element – Improved Process Development



Notes:

***RTCA SC-205:** Security Considerations. Develop guidance to leverage technology developed in the computer and communication industries for use in the aviation industry; the guidance will provide a means to achieve approval of both airborne and CNS/ATM software*

DO-264: ***Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications***

DO-178C: ***Software Considerations in Airborne Systems and Equipment Certification***

DO-248C: ***Guidelines***

DO-278A: ***Guidelines for Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) Systems Software Integrity Assurance***

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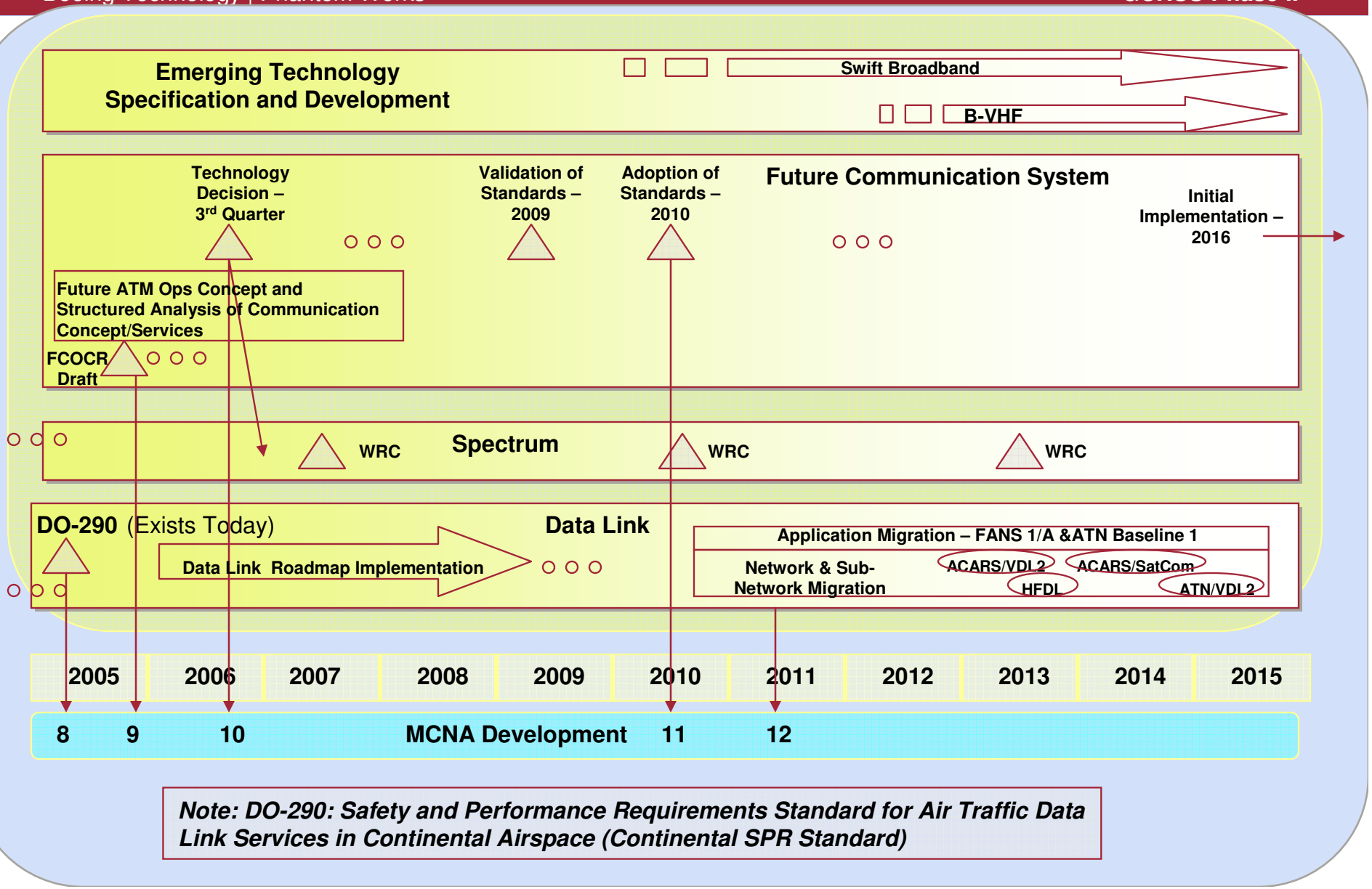
Activity 1: Environmental Element – Link Technologies

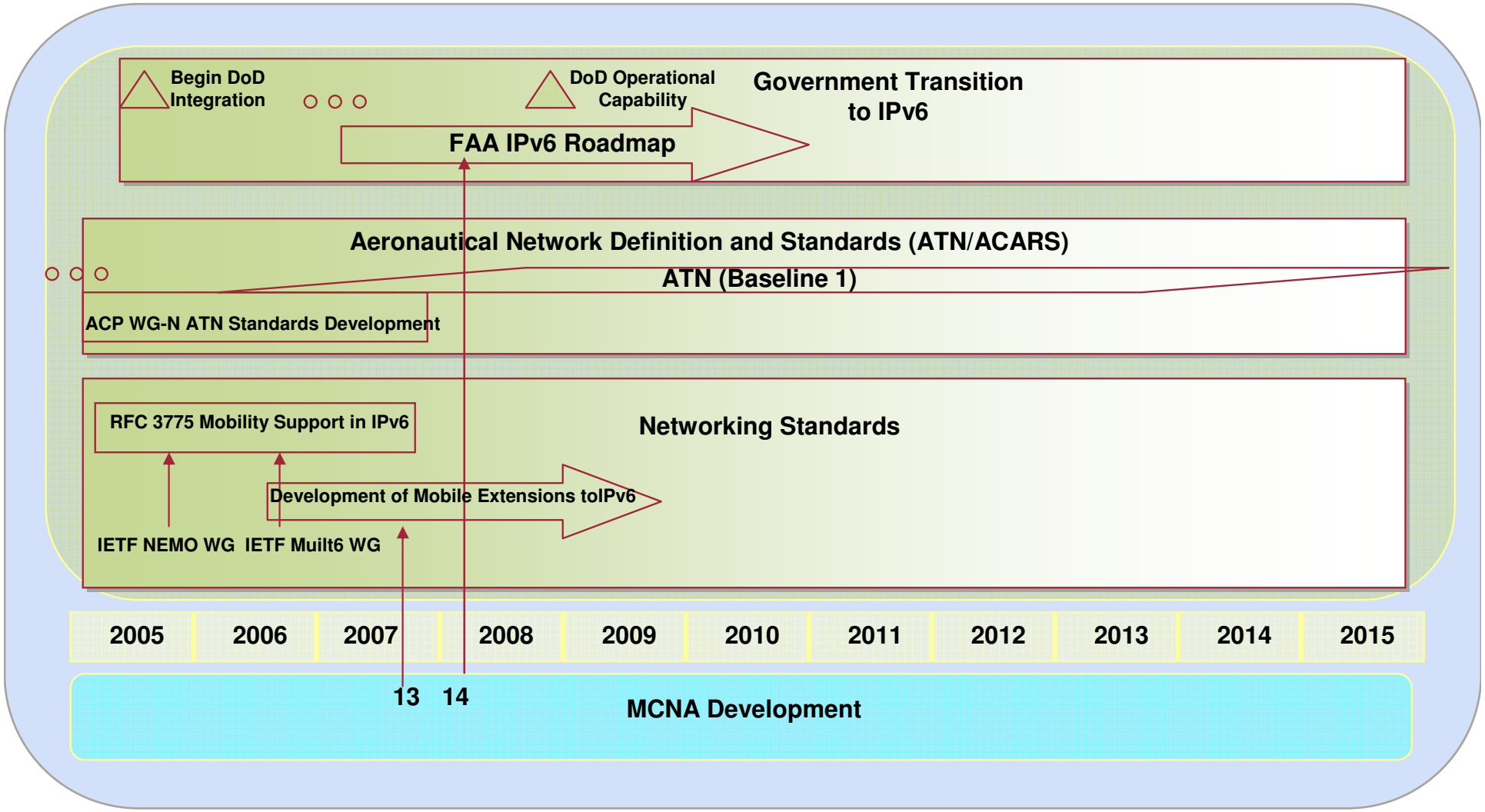


Note: DO-290: Safety and Performance Requirements Standard for Air Traffic Data Link Services in Continental Airspace (Continental SPR Standard)

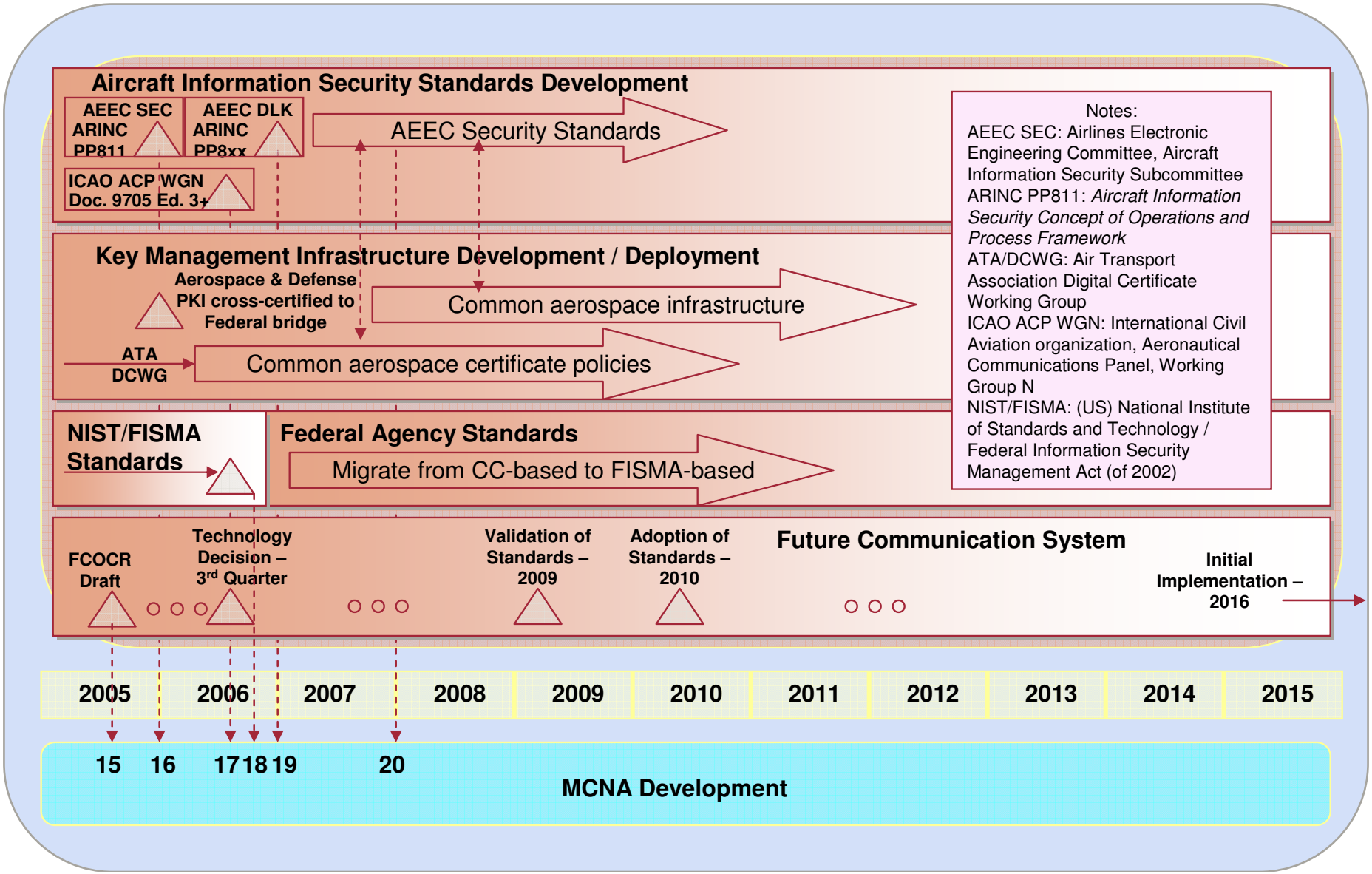
Slide 6

f1 Worried about the ITAR requirements when saying will go DoD
fc021c, 8/19/2005

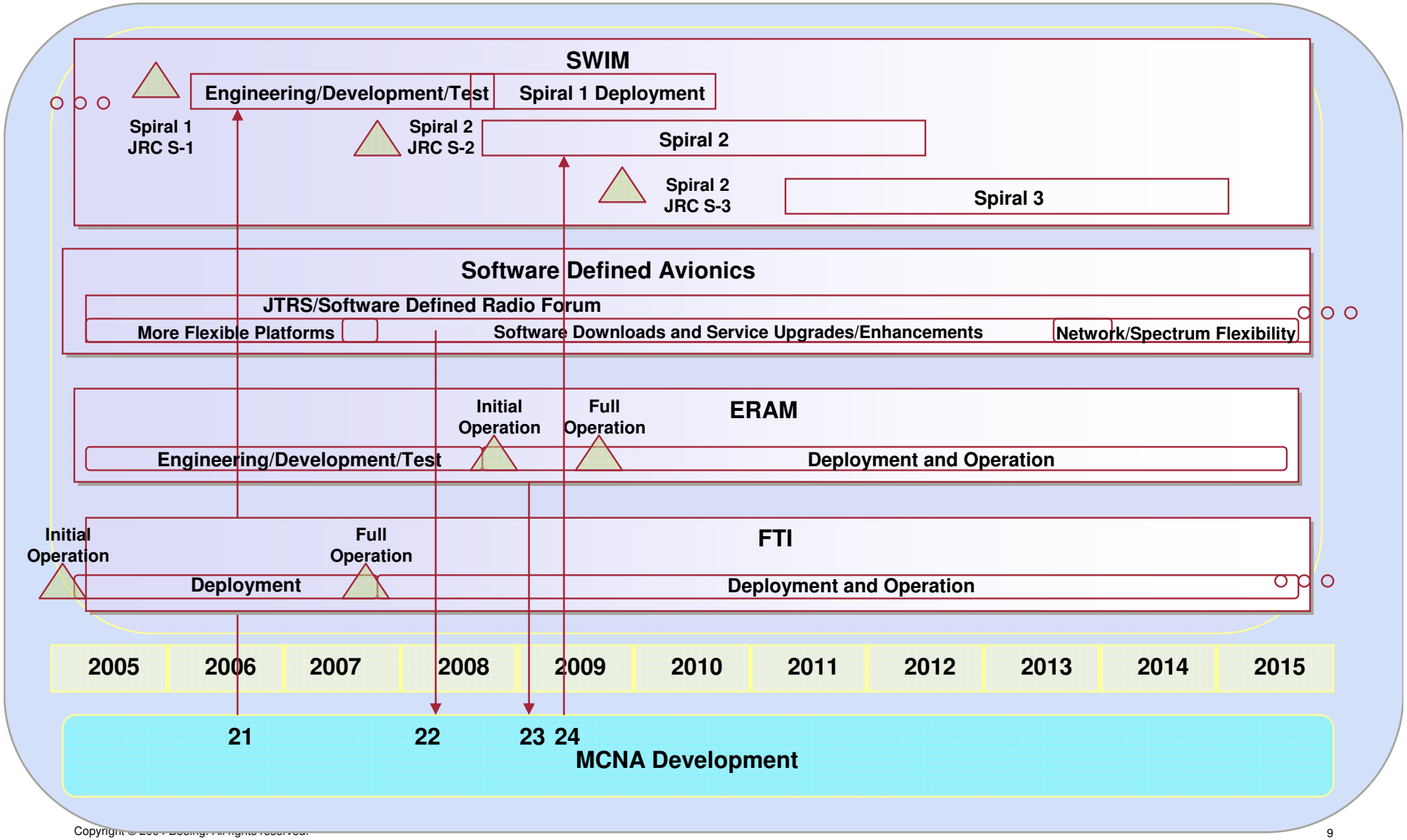
Activity 1: Environmental Element – Network Technologies



Activity 1: Environmental Element – Security



Activity 1: Environmental Element – System Integration



Activity 1: Environmental Perspective – Inputs/Outputs Summary

	Item	Category	Input/ Output	Time	Applicability	Reference
1	DO-264 Guidelines for approval of ATS Supported by data link	Improved Process Development	Input	Current	Support development of certification process for use of commercial software and systems in MCNA architecture	RTCA document descriptions
2	PARC CWG Data Link Roadmap	Improved Process Development	Input	Fall 2005	Lays out road to FAA datalinks that can be considered when validating the MCNA architecture and requirements as well as transition plan	
3	Inputs to PARC CWG RCP Definition Process	Improved Process Development	Output	Late 2005	Bring MCNA outputs and RCP issues to the CWG for consideration; participate in CWG as appropriate	
4	Inputs to SC-205 to request expanded scope and support development efforts	Improved Process Development	Output	2006	Supports MCNA inputs to defining a process for certifying commercial systems for ATC and AOC ops	RTCA SC-205 website
5	PARC CWG RCP Roadmap	Improved Process Development	Input	Early 2006	Support refinement of MCNA architecture and transition plans	
6	Updated documents DO-178C and DO-248C	Improved Process Development	Input	Late 2008, Early 2009	Supports MCNA inputs to defining a process for certifying commercial systems for ATC and AOC ops	RTCA SC-205 website and RTCA document descriptions
7	Update document DO-278A	Improved Process Development	Input	Late 2010	Supports MCNA inputs to defining a process for certifying commercial systems for ATC and AOC ops	RTCA SC-205 website and RTCA document descriptions
8	DO-290 AT data link performance & safety req.	Link Technologies	Input	Current	Support refinement of MCNA architecture and transition plans	RTCA document descriptions
9	Final Communications Operating Concept and Requirements for the Future Radio System - Draft	Link Technologies	Input	Late 2005	Support refinement of MCNA architecture and transition plans	

Activity 1: Environmental Perspective – Inputs/Outputs Summary (cont'd)

	Item	Category	Input/ Output	Time	Applicability	Reference
10	FCS Technology Decision	Link Technologies	Input	Late 2006	Should factor in to CWG Data link roadmap; consider when refining and validating MCNA architecture and requirements and transition plan	Output of WGW June 2005
11	FCS Standards	Link Technologies	Input	Mid 2010	Provides details to support detailed MCNA planning	
12	Aeronautical network capability roll-out (ACARS/VDL2, ATN, etc)	Link Technologies	Input	2011	Implementation of aeronautical network capabilities allows for refinement of MCNA architecture and issues; transition plan development; and integration experimentation	
13	Support for definition of aeronautical extensions for mobile IPv6	Network Technologies	Output	2006	Supports definition of MCNA network protocol	(Need refinement of RFC 3775 workplan)
14	Support for definition of FAA IPv6 Roadmap	Network Technologies	Output	2008	To support government transition to IPv6, it is assumed that the FAA will develop a roadmap. MCNA should participate in the definition of this plan	Used DOD transition timeline as a baseline for info
15	Final Communications Operating Concept and Requirements for the Future Radio System - Draft	Security	Input	Late 2005	Provides an initial set of operational security requirements and security categorization of information types, consistent with NIST FISMA and ARINC PP811	
16	AEEC SEC ARINC PP811	Security	Input	Early 2006	Provides an initial concept of operation for commercial aircraft information security, as well as a risk-based process framework for selecting and implementing security controls.	

Activity 1: Environmental Perspective – Inputs/Outputs Summary (cont'd)

	Item	Category	Input/ Output	Time	Applicability	Reference
17	ICAO Doc. 9705 Ed. 3+	Security	Input	2006 (?)	Enhancements to ATN Security SARPS (either as amendment to Ed. 3 or as Ed. 4) security framework to include confidentiality services.	
18	NIST/FISMA Standards	Security	Input	Late 2006	Completion of security standards and risk-based security management framework in response to FISMA legislation. Federal agencies (including DoT and FAA) directed to migrate to this process for protecting critical information systems	
19	AEEC DLK ARINC PP8xx	Security	Input	Late 2006	Standardization of security framework for protecting AOC messages; expected to follow ATN Security framework specified in ICOA Doc. 9705, Ed. 3	
20	AEEC Security Standards	Security	Input	Early 2008 and beyond	Follow-on to ARINC PP811 recommendations, expected to result in standardization of common security controls, common aerospace certificate policies, and common supporting key management infrastructure.	
21	SWIM Development	Systems Integration	Output	Early 2008	Coordinate with SWIM engineering and development activities to ensure mobile users are accommodated in SWIM architecture	SWIM timeline based on information in SWIM transition plan
22	SDA Development Activities	Systems Integration	Input	2008	Support evaluation of future avionics technologies and architectures	
23	ERAM Capabilities/ Interface Descriptions	Systems Integration	Input	2009	Support concepts for service partition and integrated mobile networks to aircraft	
24	SWIM Spiral 2 Development	Systems Integration	Input	2009	Coordinate with SWIM engineering and development activities to add additional mobile users capability in SWIM (Spiral 2)	

Activity 1: Target 2015 MCNA Concepts

- The roadmap identifies specific activities to be accomplished over the next ten years to achieve a target 2015 MCNA capability; therefore, knowledge of this vision is an important aspect of roadmap development
  - As the MCNA development effort is in its infancy, there is not a full and detailed definition of the 2015 target architecture; instead, information gathered and created during the MCNA tasks documented in this report have begun to outline the envisioned capability for the 2015 timeframe.
    - Future work may include refinement, elaboration, and validation of the vision MCNA target architecture.
  - Current target architecture concepts have been inferred from material described in or derived from the MCNA Functional Analysis report and the MCNA Transition Plan report

Activity 1: Target 2015 MCNA Concepts (cont'd)

- Based on the MCNA transition analysis, it is anticipated that existing (and potentially some new) communication capabilities will be present in the 2015 time frame to support the following mobile user communication capabilities:
  - Voice:
    - PL Voice (Service Level (SL) 1/3/4)
    - Selective Addressed Voice (SL 2)
    - Broadcast Voice (SL 1)
  - Data:
    - Messaging (SL 1/2/3)
    - Trajectory Exchange (SL 2)
    - Broadcast to A/C: (SL 2/3)
    - Broadcast from A/C (SL 2/3)
    - Ground to Air Data (SL 3)
    - Air to Ground Data (SL 3)
    - Video Exchange (SL 2)
    - C^2 (SL3)

In this list, the designation of service level has been used to describe the level of capability (or service class) within each communication service category

- **The levels generally range from 1 to 3 or 1 to 4, with 1 indicating the most stringent performance attributes and the higher numbers the more basic service qualities**
- **The activities in the MCNA roadmap should include activities that support the realization of these service classes within the NAS**

Activity 1: Target 2015 MCNA Concepts (cont'd)

- **Another view of the target architecture was created by reviewing the MCNA functions (from the functional analysis) and determining the desired/required level of capability per function by 2015**
  - **The capability level is specified in one of four ways:**
    - **Full: full deployment of the functionality throughout the NAS**
    - **Partial: partial deployment of the functionality within MCNA**
    - **Trial: functionality exists, but only for trial purposes in selected areas**
    - **None: functionality does not exist in the 2015 MCNA architecture**
- **Target Architecture Functionality**

Level 1 Function	Level 2 Function	Level 3 Function	Capability in 2015 Target Architecture	Comments
Provide Data Transport	Provide Naming and Addressing	Register Names	Partial	
		Allocate Network Addresses	Partial	Includes ACARS and ATN capability, which have rather static name allocation based upon ICAO number or tail number. With the roll-out of IPv6, more dynamic naming and addressing functions are introduced via DNS
		Resolve Address from Names	Partial	

Activity 1: Target 2015 MCNA Concepts (cont'd)

- **Target Architecture Functionality (cont'd)**

Level 1 Function	Level 2 Function	Level 3 Function	Capability in 2015 Target Architecture	Comments
Provide Data Transport	Manage Connections And Sessions	Authenticate User	Partial	These could be introduced by either secure ACARS (if ever applied) ATN version 2 or as part of new IP-based services.
		Authorize Access	Partial	
		Establish Connection/Session	Full	Generic to any datalink subnetwork (datalink capability exists in target architecture)
		Maintain Connection/Session	Full	Generic to any datalink subnetwork (datalink capability exists in target architecture)
		Terminate Connection/Session	Full	Generic to any datalink subnetwork (datalink capability exists in target architecture)
	Manage Routing Policy And Mobility	Allocate Flows to Subnetworks	Trial	Specific to applicable applications and available subnetworks (min functionality)
		Move flows between subnetworks	Trial	Gateway functionality implemented to provide this capability
		Create a subnetwork connection	Full	Generic to any datalink subnetwork (datalink capability exists in target architecture)
		Terminate subnetwork connection	Full	Generic to any datalink subnetwork (datalink capability exists in target architecture)

Activity 1: Target 2015 MCNA Concepts (cont'd)

- **Target Architecture Functionality (cont'd)**

Level 1 Function	Level 2 Function	Level 3 Function	Capability in 2015 Target Architecture	Comments
Provide Data Transport	Transport Data	Authenticate Data	Partial	
		Encrypt Data	Partial	
		Ensure Data Integrity	Full	
		Deliver packet to single user	Full	
		Deliver packet to groups of users	Partial	
		Deliver packet to all users	Partial	
	Provide QoS	Prioritize Packet Delivery	Partial	
		Pre-empt lower priority comm	Partial	
		Shape Traffic	Partial	
		Police Traffic	Partial	
Manage Data Transport	Manage Faults		Partial	Should tie in to FTI (and SWIM) capabilities
	Manage Configuration		Partial	Should tie in to FTI (and SWIM) capabilities
	Manage Accounting		Partial	Should tie in to FTI (and SWIM) capabilities
	Manage Performance		Partial	Should tie in to FTI (and SWIM) capabilities
	Manage Security		Partial	Should tie in to FTI (and SWIM) capabilities

Activity 2: Gap Analysis

- Next step was the identification of requirements, technology, certification, and/or cultural gaps or shortcomings specific to the implementation of the MCNA architecture
  - During the development of MCNA requirements, architecture concepts (both avionics and ground), and transition plans, a range of shortcomings were identified and documented
  - Recommendations to address the 26 identified gaps were also formulated

MCNA Shortcomings

	Shortcoming	Category
1	RCP does not clearly provide provisions to meet a service using multiple systems	Requirements
2	RCP linearly divides expiration time allocations (in many cases, not necessarily all)	Requirements
3	RCP seems to lack sufficient operational analysis behind many quantified performance requirements	Requirements
4	Certain requirements such as multi-homing, policy based routing and priority/pre-emption are not clearly defined and universally applied	Requirements
5 - 6	IP lacks sufficient mobility and multihoming capabilities as defined by ATN	Technology
7	New IP-based communication links should be able to support multiple classes of communications to provide better justification to equip	Technology / Cultural
8	Lack of a mechanism to multicast messages to managed groups of users	Technology
9	Physical connection between A-G transceivers and sectors limits the ability to transition towards an agile NAS	Technology / Culture
10	Lack of masquerading prevention in voice services	Technology / Culture
11	Lack of masquerading in data services	Technology
12	Certification cost of commercial avionics is a significant barrier to the introduction of additional low cost avionics to also enhance ATS communications	Certification
13	During the near term, ACARS, ATN and IP links/networks will all coexist. Need a means to integrate these disparate networks to provide an integrated communication service offering.	Technology
14	Need means of supporting address mobility for IP while maintaining efficient routing	Technology
15	Traditional transport layer protocols (i.e. TCP) implements congestion control mechanisms that may not be efficient in a wireless environment	Technology

MCNA Shortcomings (cont'd)

	Shortcoming	Category
16	May need to convert application layer protocol data formats for transport over bandwidth constrained wireless links	Technology
17	Need Topology Control Mechanism for the ad hoc MCNA network	Technology
18	Need to determine MCNA routing protocols that coordinate efficiently with existing and planned link layer protocols and what routing protocols are offered by FTI, ATN, etc	Technology
19	Some MCNA applications may require multicast routing capabilities	Technology
20	Conclusion 1: There is currently no FAA acknowledged process in place by which a commercial system can be approved for the transmission of safety services, including both ATS and AOC services.	Certification
21	There is currently no FAA acknowledged process in place by which a commercial system can be approved for the transmission of safety services, including both ATS and AOC services.	Certification
22	There is no widely acknowledged paradigm for the use of commercial terrestrial telecommunications infrastructure for safety information, even though this use occurs every day.	Certification
23 - 25	There is currently no FAA acknowledged process in place by which avionics suitable for use with a commercial system can be approved for the transmission of safety services, safety services, including both ATS and AOC services. It is uncertain which organization within FAA would receive or approve such documentation as a basis for a TSO- or PMA-based approval. Including both ATS and AOC services.	Certification
26	Once the significant questions raised regarding system and avionics certification are resolved, the current aircraft certification process appears to be sufficient to support the approval for individual services. However, the current process may not be sufficient for anticipated future RCP applications.	Certification

Activity 3: Roadmap Activity Definition

- To address the defined target 2015 architecture and associated gaps, three developmental steps were defined
  - Phase I: System Engineering Product Refinement; Process/Technology Investigation and Definition; and Experimentation Planning
  - Phase II: Technology Experimentation/Validation; Initial SWIM Integration; and Service Partitioning/Network Integration Planning
  - Phase III: Technology demonstration; initial service partitioning/integrated network validation; and full SWIM integration

Activity 3: Roadmap Activity Definition - Phase I

- Phase I: System Engineering Product Refinement; Process/Technology Investigation and Definition; and Experimentation Planning
  - This phase supported two major activities:
    - On-going System Engineering Analysis and Process Development:
      - Refinement/validation of MCNA architecture/requirements
      - Refinement of gap analysis
      - Definition of certification processes and documentation to address the use of commercial software/systems in ATC and AOC applications
      - Support of definition of RCP through structured analysis of required communication functions/capabilities
    - Experimentation Planning and Technology Investigation
      - Development of plans for conducting experiments specific to the role of technology required for MCNA
      - Investigation and development of MCNA network security requirements and technologies
      - Extension of mobile networking protocols to the aeronautical environment

Activity 3: Roadmap Activity Definition– Phase II

- Phase II: Technology Experimentation/Validation; Initial SWIM Integration; and Service Partitioning/Network Integration Planning
  - This phase included:
    - Introduction of initial concepts of the future avionics architecture, including support for standardization of future software defined avionics
    - Definition and evaluation of service partitioning and network integration concepts (including simulation/emulation)
    - Validation of data link technologies for supporting required communication services classes
    - Technology experimentation
    - Initial SWIM Integration
    - Total system integration (all stakeholders) and global interoperability planning

Activity 3: Roadmap Activity Definition - Phase III

- Phase III: Technology demonstration; initial service partitioning/integrated network validation; and full SWIM integration
  - This phase included:
    - Continued technology experimentation and technology demonstration
    - Evaluation and validation of service partitioning and network integration architectures
    - Demonstration of the initial integrated network capability (for defined communication services and applications)
    - Full integration of MCNA into SWIM service infrastructure

Activity 3: Definition of Specific Roadmap Elements

- For each MCNA Development Phase, specific activities (or roadmap elements) were defined
  - These elements addressed the key items noted on previous slides for each development phase
  - Included elements that address gaps uncovered during gap analysis
  - Incorporated elements that accommodate recommended SED activities
- Some roadmap activities are relatively straight-forward, while other activities are broader in scope and should be refined and detailed during follow-on systems engineering activities supporting MCNA development

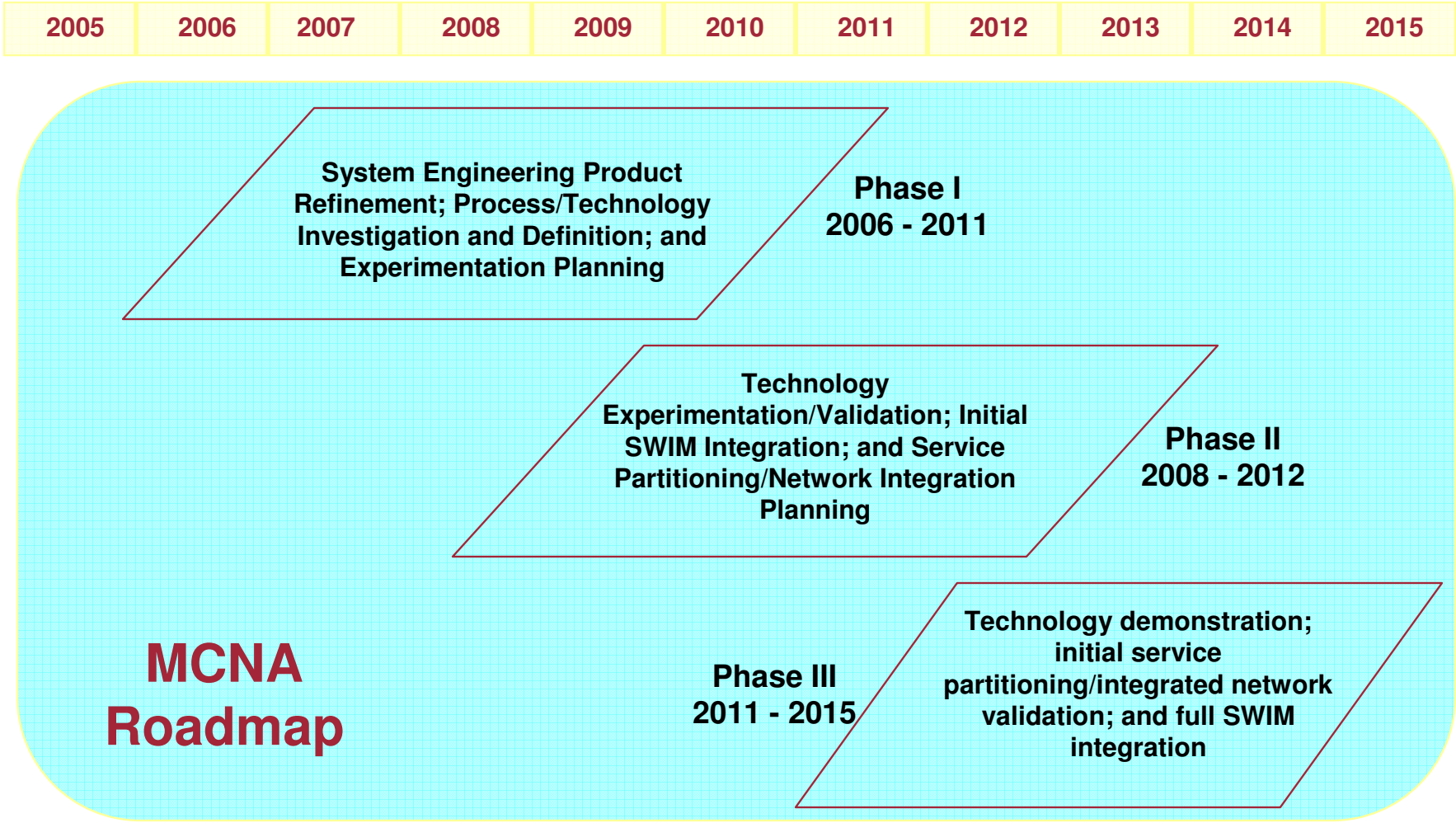
Activity 3: Definition of Specific Roadmap Elements

ID	MCNA Roadmap Element	Developmental Step
1	Refinement of Architecture, Requirements, Transition Plan	Phase I
2	Certification Process Definition/Standardization Support: Develop process for submission and review of relevant data supporting the certification of Commercial Systems/Software for AOC and ATS applications	Phase I
3	Certification Documentation Definition Support: Define required documentation for the defined process of certifying commercial systems for AOC and ATS applications	Phase I
4	Structured Analysis of Communication Services and RCP: Participate in RCP definition of end-to-end performance (including support for safety analysis)	Phase I
5	IPv6 Mobility Standards & IP-based Datalink Development (includes participation in Mobile IP Standards Organizations to define an aeronautical IPv6 with appropriate security, mobility and peer-to-peer support)	Phase I
6	MCNA Network Security Analysis	Phase I
7	Experimentation Planning: Defining and planning specific experimental tasks supporting MCNA technologies and architecture concepts	Phase I
8	Future Avionics Technologies (e.g. SDA) and Architecture Evaluation	Phase II
9	Security Impact Analysis and Requirements Development	Phase II
10	SWIM Testbed Integration (initial mobile user capability for SWIM Spiral 1)	Phase II
11	Evaluation of Service Partitioning/Network Integration Technologies and Concepts	Phase II
12	Conduct Technology Experimentation	Phase II
13	Service Partitioning and Network Experimentation	Phase III
14	MCNA Technology Demonstration	Phase III
15	Additional SWIM Capability to Mobile User and Native Network Centric Operation Engineering	Phase III
16	Integrated Network Demonstration	Phase III

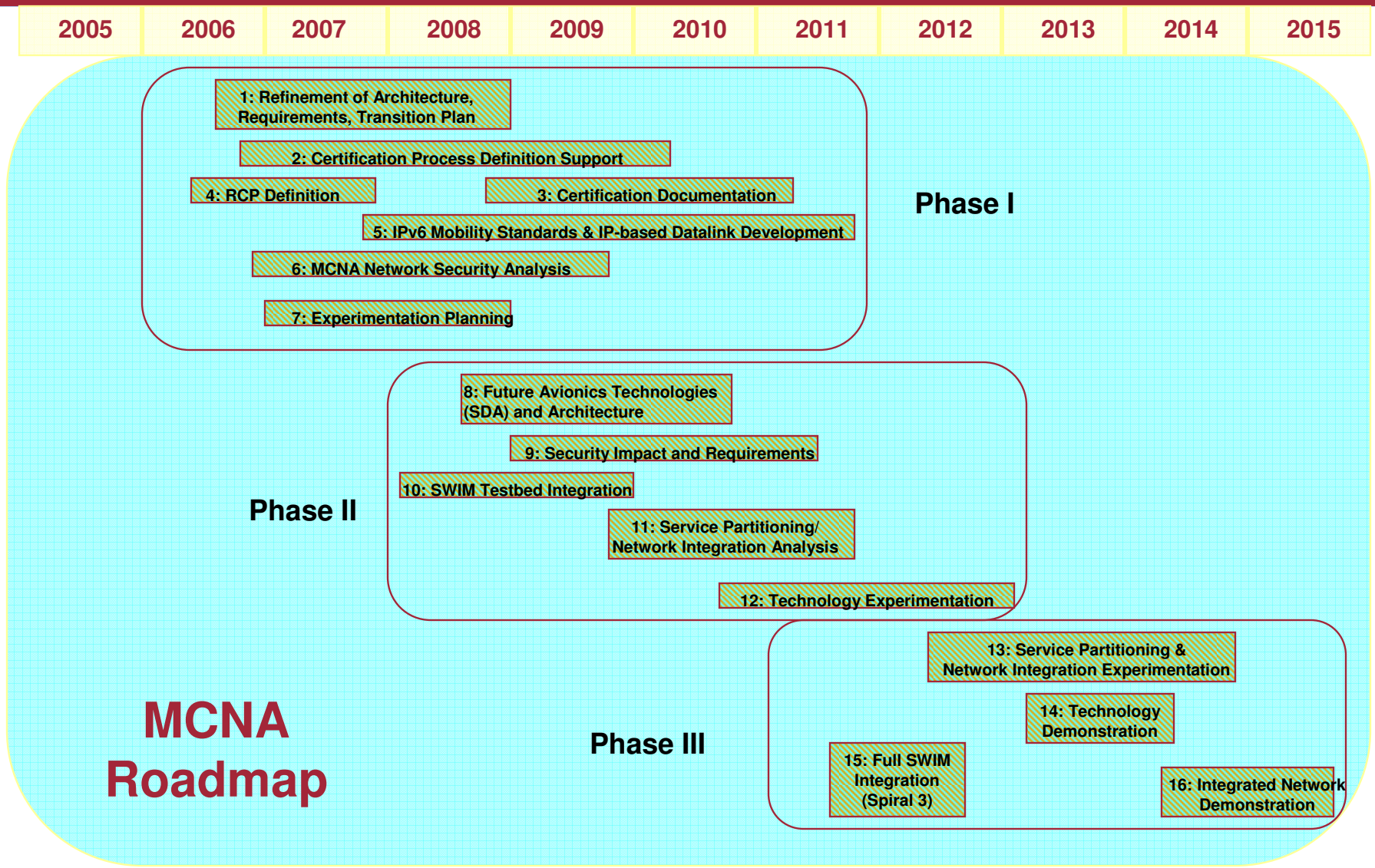
Activity 4: MCNA Roadmap Development

- This activity included
  - 1) Development of the actual MCNA roadmaps (adding the time context to the roadmap elements)
    - A high-level overview of the three planned phases of MCNA development over the next ten years
    - A more detailed layout of recommended activities to continue MCNA development and implementation over the next ten years
      - Accommodates inter-relationships among roadmap activities and relationships to environmental activities
  - 2) Roadmap traceability

Activity 4: MCNA Roadmap View: High Level



Activity 4: MCNA Roadmap View: Detailed



Traceability

- To ensure that the elements of the MCNA roadmap meet the roadmap objectives and the roadmap is complete, traceability was performed between the elements of the roadmap and related MCNA material developed as part of this study
- Specifically, traceability was performed between the roadmap elements and the following:
  - Gap/Shortcomings (defined during the gap analysis): to ensure that roadmap elements exist to address all identified shortcomings
  - SED Recommendations: to ensure the recommended simulation, emulation and demonstration activities were addressed by roadmap elements
  - MCNA functions: to ensure the roadmap elements lead to the level of capability expected in 2015
  - Environmental Inputs/Outputs: to ensure that inputs to or outputs from MCNA development activities to specific environmental activities are associated with specific roadmap elements/activities

MCNA Roadmap Traceability Matrix

ID	MCNA Roadmap Element	Traceability to Defined Gaps	Traceability to SED Recommendations	Traceability to MCNA Functions	Traceability to Envir. Inputs & Outputs
1	Refinement of Architecture, Requirements, Transition Plan	5,8,9		ALL	2, 3, 10, 11
2	Certification Process Definition/Standardization Support: Develop process for submission and review of relevant data supporting the certification of Commercial Systems/Software for AOC and ATS applications	12, 20, 22, 23, 24, 25, 26			1, 4, 6, 7
3	Certification Documentation Definition Support: Define required documentation for the defined process of certifying commercial systems for AOC and ATS applications	21			1, 4, 6, 7
4	Structured Analysis of Communication Services and RCP: Participate in RCP definition of end-to-end performance (including support for safety analysis)	1, 2, 3, 4, 26			2, 3, 5
5	IPv6 Mobility Standards & IP-based Datalink Development (includes participation in Mobile IP Standards Organizations to define an aeronautical IPv6 with appropriate security, mobility and peer-to-peer support)	6, 8, 14, 15, 16, 17, 18, 19, 25	Model and demonstrate mobility protocols and dynamic routing	Transport Data; Provide QoS; Provide Naming and Addressing; Manage Routing Policy and Mobility	13, 14

MCNA Roadmap Traceability Matrix (cont'd)

ID	MCNA Roadmap Element	Traceability to Defined Gaps	Traceability to SED Recommendations	Traceability to MCNA Functions	Traceability to Envir. Inputs & Outputs
6	MCNA Network Security Analysis	10, 11		Provide QoS	8, 15, 16, 17, 18, 19, 20
7	Experimentation Planning: Defining and planning specific experimental tasks supporting MCNA technologies and architecture concepts	5, 6, 7, 8, 10, 11, 14			12, 23
8	Future Avionics Technologies (e.g. SDA) and Architecture Evaluation		Simulation/emulate avionic architectures to evaluate support for MCNA scenarios		10, 11, 22
9	Security Impact Analysis and Requirements Development	10, 11		Provide QoS; Manage Security	8, 15, 16, 17, 18, 19, 20
10	SWIM Testbed Integration (initial mobile user capability for SWIM Spiral 1)	5, 9, 16	Emulation mobile user interface to SWIM	Manage Connections and Sessions; Transport Data	21

MCNA Roadmap Traceability Matrix (cont'd)

ID	MCNA Roadmap Element	Traceability to Defined Gaps	Traceability to SED Recommendations	Traceability to MCNA Functions	Traceability to Envir. Inputs & Outputs
11	Evaluation of Service Partitioning/Network Integration Technologies and Concepts	13	Dynamic routing/ service partitioning algorithms and architecture modeling	Manage Routing Policy and Mobility	12
12	Conduct Technology Experimentation	7, 8, 10, 11, 14	Model exiting and planned comm. lists to evaluate ability to provide RCP; evaluation of mobility protocols		12
13	Service Partitioning and Network Experimentation	13	Model and evaluate performance of integrated network and service portioning architecture		
14	MCNA Technology Demonstration	7, 8, 10, 11	Lab/Flight Demo of mobility protocols and dynamic routing		
15	Additional SWIM Capability to Mobile User and Native Network Centric Operation Engineering				24
16	Integrated Network Demonstration	9	Flight Demo		